Turkish Journal of Science & Technology
17(2), 321-328, 2022

Research Paper
https://doi.org/10.55525/tjst.1103449

ARTIFICIAL INTELLIGENCE BASED SMART INTERCHANGE SYSTEM IN SMART URBANIZATION

Emrullah EZBERCİ [1*], Derya AVCI [2]
[1] Institute of Science and Technology, Firat University, Elazığ, Turkey
[2] Department of Computer Technologies, Vocational School of Technical Sciences, Firat University, Elazig, Turkey
[*1]emrullah_76@hotmail.com, [2]davci@firat.edu.tr

(Geliş/Received: 14/04/2022; Kabul/Accepted: 11/07/2022)

Abstract: The duration of the smart intersection system lights is determined automatically according to the nearest busy. The vehicle at the intersection with the camera is calculated by the image processing process. optimizing the signaling time in traffic signaling. It will be passed to be passed by a system that can be reached later. Also the system can be entered with this remote central management. Manually switch to roads. In this study, it is a smart intersection system used with special permission from Malatya Metropolitan Municipality transportation units. These studies and the benefits they have provided are highlighted. In addition, DARKNET's real-time object detection YOLOV3 deep learning model is used within the scope of in-vehicle real-time traffic system from data images on websites for traffic. The vehicles are placed in the targeted and future-determined database. Positive signaling with information from the designed Process-Based Intersection Management System. Agricultural bounty takes advantage of little stealing gases to be grown to take advantage of time and small items. A clean environment will be created.

Key words: Smart City, Smart Transportation, Smart Junction, Image Processing, Deep Learning, Darknet, Yolov3

Akıllı Şehircilikte Yapay Zeka Tabanlı Akıllı Kavşak Sistemi

Öz: Akıllı kavşak sistemlerinde trafik ışıklarının süreleri araç yoğunluğa göre otomatik olarak belirlenir. Kamera sistemi ile kavşaktaki araç sayıları görüntü işleme yöntemleriyle hesaplanmaktadır. Böylelikle araç sayısına göre sinyalizasyondaki bekleme süresi optimize edilmektedir. Daha sonra araç yoğunluğu fazla olan tarafa sistem tarafından geçiş üstünlüğü verilerek trafik yoğunluğunun önüne geçilmektedir. Ayrıca bu sistemde uzaktan merkezi yönetim ile müdahale edilebilmektedir. Yollara geçiş üstünlükleri manuel olarak verilebilir. Bu çalışmada, Malatya Büyük Şehir Belediyesi ulaşım biriminden alınan özel izinle kullanılan akıllı kavşak sistemi incelenmiştir. Bu sistemin çalışması ve sağlamış olduğu faydalar vurgulanmıştır. Ayrıca kavşaklardaki veri görüntülerinden araç tespiti için açık kaynaklı sinir ağı çerçevesi olan DARKNET'in gerçek zamanlı nesne algılama sistemi YOLOV3 derin öğrenme modeli kullanılmıştır. Araçların sayımı ve sınıflandırılması anlık tespit edilerek veri tabanına kaydedilmiştir. Tasarlanan Görüntü İşleme Tabanlı Kavşak Yönetim Sistemi ara yüzü ile anlık bilgilerle sinyalizasyonun dinamik olması sağlanmıştır. Böylelikle yakıt tasarrufu, zaman ve araçların egzozlarından çevreye daha az zehirli gazların yayılması sağlanmaktadır. Temiz çevre oluşumuna katkı sağlanmış olunacaktır.

Anahtar kelimeler: Akıllı Şehir, Akıllı Ulaşım, Akıllı Kavşak, Görüntü İşleme, Derin Öğrenme, Darknet, Yolov3.

1. Introductıon

Due to the increase in population in urbanization, there is a significant increase in the number of vehicles used in cities. This traffic density causes problems such as time, environmental pollution and unnecessary fuel consumption. In order to solve these problems, intelligent systems developed by using information technologies are needed, especially in order to prevent the densities of vehicles waiting at the lights and to provide fast transition. There are many parameters for making transportation in cities smart. The most important of these is to reduce the waiting times of vehicles at traffic lights and to prevent vehicle density in these areas. As a result, smart intersection applications have been developed. Magnetic-based, ultrasonic-based and image-based systems are used in smart junction applications [1]. In particular, image-based systems are preferred due to the versatility of functionality, ease of installation, simplicity of management and long durability. The images taken in real time with the camera in these systems are detected instantly with the image processing software, and the traffic flow is directed. The lights that control the traffic flow do not have a certain duration, but the duration of the lights is determined according to the vehicle density. The increasing population in urban areas and the number of vehicles make it difficult to control the roads. The most important reason for this problem is the lack of instant control [2].

* Corresponding author: emrullah_76@hotmail.com.tr ORCID Number of authors: [1] 0000-0002-8960-1456, [2] 0000-0002-5204-0501

Today, they are systems created with signal detectors laid under the road to control traffic signaling. Since the installation, operation, maintenance and cost of this system is high, artificial intelligence-based camera and vehicle detection systems have been developed [3].
In recent years, a high level of success has been achieved in studies on image processing. Deep learning algorithms play an important role in this success. These algorithms are used in many fields with great accuracy, especially in the detection and classification of objects in the field of image, sound analysis, robotics, gene, autonomous systems and medicine [4].
Many areas from transportation to finding parking spaces, from traffic density to autonomous vehicle development and target detection in the defense field are carried out with vehicle detection systems [5]. The necessity of using deep learning, machine learning methods and image processing algorithms has emerged in order to provide faster and more accurate description of the performance and scalability of the systems, especially in the images coming from drones and traffic cameras [6]. Convolutional network model in deep learning methods and YOLO algorithms in image processing and object detection methods come to the fore [7,8].
Studies in the literature on smart intersection applications were examined. In one study, an autonomous traffic light control was performed. In the study based on image processing technology prepared with Python software language and an open source microscopic software, SUMO, comparisons were made over four different traffic density scenarios [9]. In the study using image processing techniques, an online software that can generate statistical data by looking at the current traffic has been developed. Vehicle detection and tracking were performed using deep learning and machine learning techniques on the videos of five selected intersections and nine highways [10]. He conducted a study using deep Q learning technique to combine on a four-way intersection to solve traffic congestion. The traffic intersection environment and traffic scenario in which this model will be applied has been created on the traffic simulation software SUMO [11]. He did a study against the problems caused by some traffic methods based on timers or human control. In the study, a real-time traffic management system using contrast enhancement and fuzzy logic controller was created for morphological operators [12]. A study based on LSTM (Long Short-Term Memory) neural network has been carried out for non-relational cases of traffic flow. By using the data obtained from connected and autonomous devices as inputs, the density of traffic during free flow, vehicle transit and congested times was estimated [13]. It has developed an adaptive, real-time and density-based traffic light control system. According to the model, with the help of cameras, the lanes on the roads are monitored and images, the number of vehicles in each lane and the queue length are determined by using image processing techniques [14]. He conducted a study using real data for the intelligent control of traffic signaling at a four-way intersection. In the study, the traffic flow was controlled with fuzzy logic, classical fixed time management [15]. As a solution proposal to traffic congestion, a smart and automatic traffic control system and a system that determines the light durations by optimizing the traffic light time becomes the traffic controller [16]. In order to minimize the waiting time and queue length in traffic, a combination of optimal general type-2 fuzzy logic controller and modified backtracking search algorithm techniques is used [17].
The smart intersection system, which is used with a special permission from the Malatya Metropolitan Municipality transportation unit, has been examined. Classical image processing technologies are used in smart intersection systems of Malatya Metropolitan Municipality. In this study, contrary to traditional image processing algorithms, with deep learning, which is an artificial intelligence technology, the vehicles in the lights are detected, the number of vehicles is found and the light durations are changed dynamically. In addition, with the designed Image Processing Based Intersection Management System interface, it is ensured that the signaling is dynamic with instant information.

2. Material Method

In this study, traffic video images taken from Malatya Metropolitan Municipality were detected and counted by using deep learning model. In addition, YOLO, which uses the convolutional neural network model, was used for object detection and recognition. Then, a model was developed for adjusting the waiting times of traffic lights by looking at the vehicle density in the traffic. In order to realize a model with deep learning, the system was created by first preparing the data set, structuring the convolutional neural network to be used in the training, and finally obtaining the model weights. With its designed interface, it is ensured that the signaling is dynamic with instant information.

2.1. Preparation of the Data Set

Within the scope of the study, traffic videos were taken from certain intersections of the city with a camera system by taking special permission from Malatya Metropolitan Municipality Transportation Department. These images were transformed into separate image frames every 10 seconds by going through certain processes. A data set consisting of 7200 images in total was obtained. Then, each image frame was examined and repetitive and inappropriate images were removed from the data set. At the end of the process, approximately 1650 images were used for training. Of these images, 80% were adjusted randomly for training and 20% for testing. Thus, it was tried to prevent the occurrence of data memorization error of the artificial neural network model. Examples of data sets used are shown in Figure 1. In Figure 2, examples of inappropriate data extracted from the data set are shown.

Figure 1. Dataset example

Figure 2. Inappropriate data

2.2. Labeling of Data

The prepared data must be labeled in order to be able to use it in education with the supervised learning method. The object belonging to the "tool" class in each image is labeled with bounding boxes, and a file with the txt extension is created in which the coordinates with the same file name as the image file are kept. Figure 3 shows the labeling of the data.

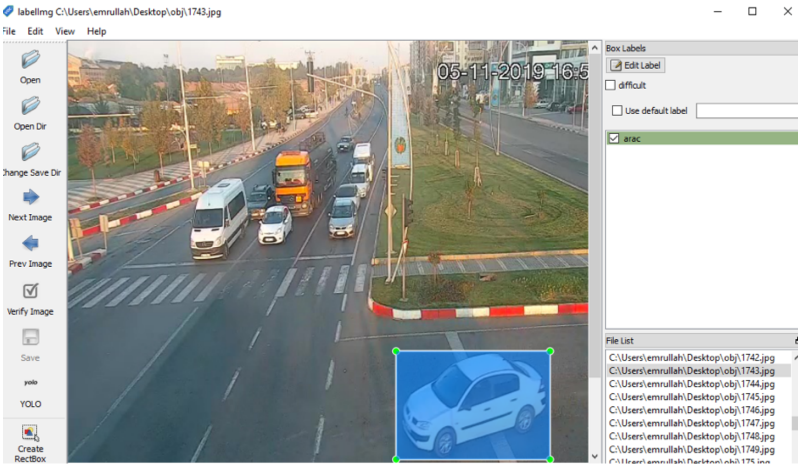

Figure 3. Labeling of the data

2.3. Training the Model

Google Colab was preferred for training. Google Colab environment was used because it provides training with CPU, Tesla K80 GPU and TPU. Since convolutional neural network is used for training, GPU environment is preferred. Before starting the training, Darknet files and pre-trained weights for YOLOV3 are loaded into the system. In the Yolov3.cfg file, the number of classes is determined as 1, the number of filters 18, and max_batches 2000 steps 1600, 1800, respectively. As seen in Figure 4, the training was completed with 1400 iterations. At the beginning of the training, the error rate decreased from 18 to 0.69. In other words, improvements were seen from the beginning to the end of the training. Appropriate weights were determined at the end of the training.

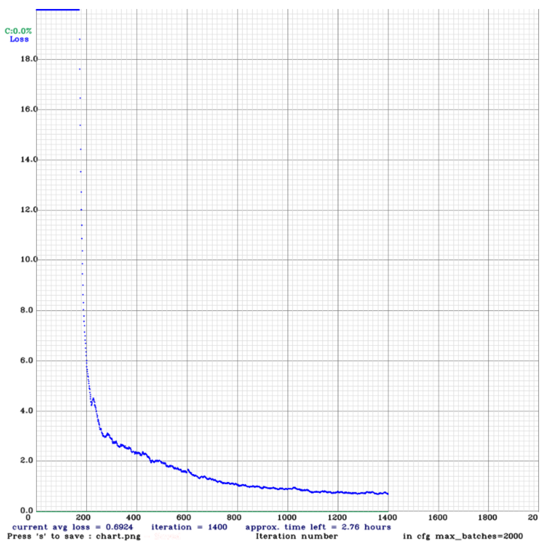

Figure 4. The training iteration graph of the model

After the training was completed, the weights and data were tested and the prediction event was realized in 91.383000 milliseconds. Figure 5 shows the testing process of the model.

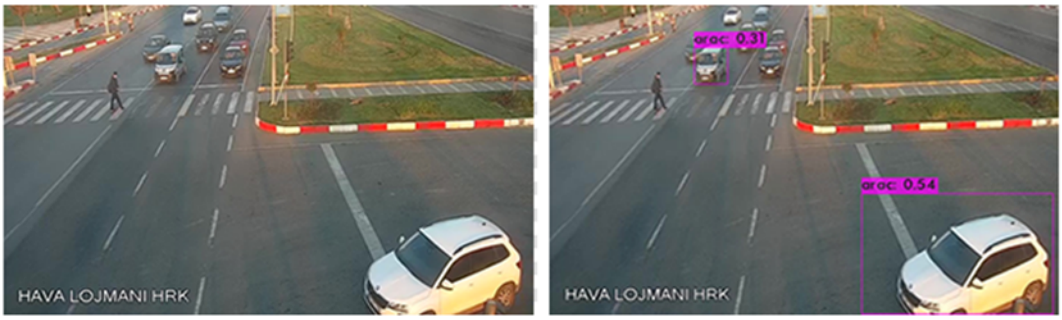

Figure 5. Testing the model

2.4. Image Processing Based Intersection Management System

In intersection applications where there is a traffic light, traffic signaling systems are formed with fixed light durations. The red and green light durations are determined beforehand, and traffic flows at fixed times. However, this system, which is applied due to the increasing vehicle density, eliminates problems such as time loss, environmental pollution and economic loss caused by unnecessary waiting times. With the developed system, the vehicles waiting at the red light at the intersections are counted and the green light durations are determined dynamically. Image Processing Based Intersection Management System interface was implemented using CSharp programming language. Yolov3 algorithm was preferred as a deep learning algorithm. Aluros of yolov3, a real-time object detection algorithm in Image Processing Based Intersection Management System. The Yolo csharp library is used. Image Processing Based Intersection Management System is shown in Figure 6.

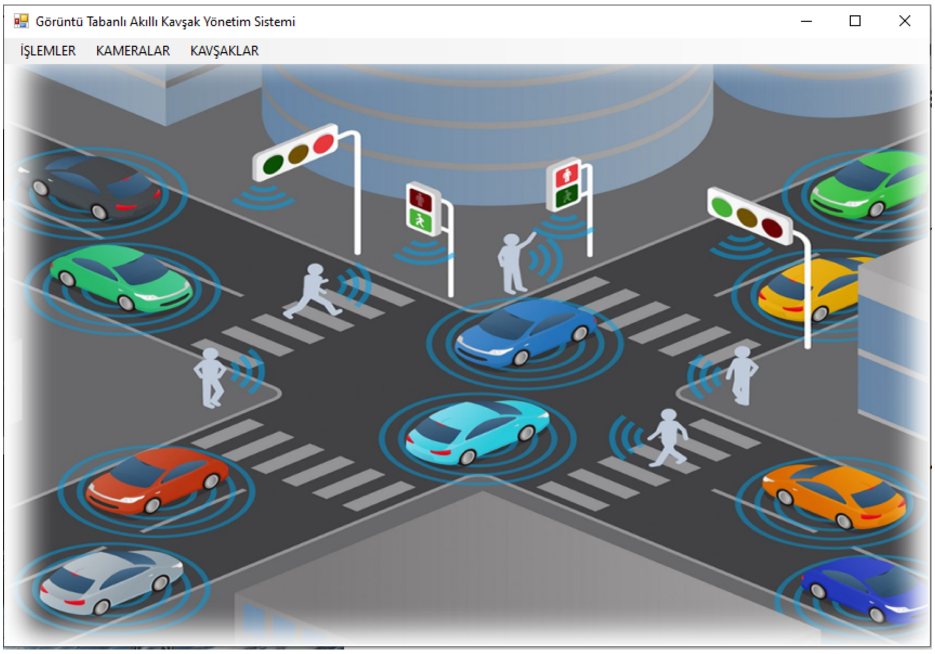

Figure 6. The training iteration graph of the model

In this study, intersection images of the smart intersection application used by Malatya Metropolitan Municipality are used as test data. As seen in Figure 7, the video images taken from the vehicle counting cameras at the intersections were converted to the appropriate resolution and transferred to the system we created. With the prepared application, it has been observed that the intersection light durations work dynamically according to the number of vehicles from the images given to the system at a four-light intersection. When the system first started, the first lamp at the intersection started with a green light and the light duration was determined as t1=15 seconds. The lights of the other second, third and fourth lamps were assigned as red and their light durations were assigned as t2=200, t3=200 and t4=200. The aim here is to determine the green light duration of the second lamp, which comes after it, before the green light period of the first lamp ends. Taking an image from the intersection over the designed system is shown in Figure 7.

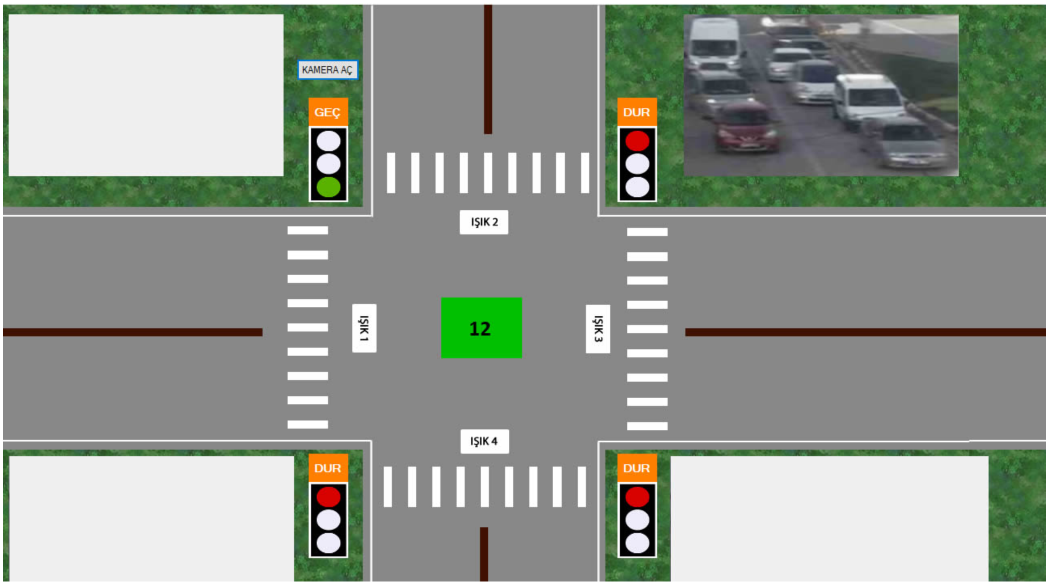

Figure 7. Getting an image of the intersection

Since the light durations in dynamic intersection systems differ according to each situation, the waiting or crossing times are not shown on the traffic boards. Here, when the green light duration of the first light reaches the seventh second determined by us, the images of the vehicles waiting at the red light of the second light are sent to the system. The system performs the counting of waiting vehicles with object recognition detection using a deep learning algorithm.

3. Results and discussion

In this study, a simulation of the dynamical realization of traffic light signaling was carried out with the image processing technique used in smart intersection systems. In this system, deep learning method was used to determine the number of vehicles waiting at the light. Learning weights were created with a loss value of 0.6924 in the training made on the yolov3 algorithm for the data created in the method implemented. By using these weights on the system, it is ensured that the light durations at the intersection are adjusted dynamically, not statically.

In Table 1, features such as location information, width and height of detected objects are shown. It is possible to access this information from within the system. In Table 2, green light durations are given according to the number of vehicles at the lights. After the number of vehicles in the image is determined, this value is sent to the green light duration method.

Table 1. Properties of detected objects

Type	Confidence Value	Horizontal Position	Vertical Position	Width	Height
car	0,563400387763	198	110	96	109
car	0,351490288972	179	92	151	182

car	0,346583276987	137	72	63	97
car	0,287773132324	23	121	93	128
car	0,477845072746	189	101	86	91

Table 2. Green light times according to the number of vehicles

Number of Vehicles	**Green Light Duration**
Number of Vehicles >= 0 or Number of Vehicles <15	15 second
Number of Vehicles >= 15 or Number of Vehicles < 25	25 second
Number of Vehicles >=25	40 second

Especially today, the success rate of deep learning algorithms in object recognition is very good. With the model we prepared, it was seen from the pictures given to the system at an intersection consisting of four lights, that the system showed a great deal of accuracy in the detection and number of vehicles. Here, a particularly good camera system should be chosen. In vehicle counting, green light times are determined instantly according to the number of vehicles, thus ensuring a fast traffic flow. Thanks to the speed of the Yolov3 algorithm in instant object detection, the system works without hesitation.

Imaging-based smart intersection application system work machines are used [18]. In classical processes, attributes are determined and displayed by processes such as graying, masking, and backgrounding. In the deep method used, it is realized by the convolutional nerve. It is to achieve great success in time and feature extraction. In the videonet selection planned in 2012 [19], deep learning in AlexNet [20] achieved great success with an error rate of %15 and it is realized with a high planned between % 95 - 100 within millimeters of the real-time planned image during the working time.

Intelligent intersection systems are both easy to install and easy to maintain with image processing systems. When you see which road is busy at the intersection, the green light duration can be increased by intervening only the light duration of that road. Thanks to this system, it helps to realize not only light durations but also many other functions. They are systems that can be used especially in urban security applications. For example, these systems are used in operations such as finding a stolen vehicle or tracking and finding a wanted plate.

Resources

[1] Yaldiz, F. (2010). Development of image-based vehicle detection system in traffic automation and implementation with FPGA.

[2] Jadhav, P., Kelkar, P., Patil, K., & Thorat, S. (2016). Smart traffic control system using image processing. International Research Journal of Engineering and Technology (IRJET), 3(3), 2395-0056.

[3] Pazar, Ş., Bulut, M., & Uysal, C. (2020). Development of Artificial Intelligence Based Vehicle Detection System. Journal of Scientific, Technology and Engineering Research, 1(1), 31-37.

[4] Tan, Z. (2019). Vehicle classification with the help of deep learning (Master's thesis, Fırat University, Institute of Science and Technology).

[5] Alyuruk, M. (2020). Chapter 18 Intelligent Transportation Systems and the Future of Transportation. Transforming Professions and Industries in the Digital Future.

[6] Azimjonov, J. (2021). Development of real-time vision-based traffic flow information computing systems for intersections and highways.

[7] Bulbul, H. (2020). Real Time Vehicle Detection Using Deep Learning Methods.

[8] Dikbayir, H. S., & Bulbul, H. I.(2020). Real Time Vehicle Detection Using Deep Learning Methods. Tubaw Science Journal, 13(3), 1-14.

[9] Oguzhan, A.(2021) Autonomous traffic lights control and optimization, Istanbul University.

[10] Azimjonov, J. (2021). Development of real-time vision-based traffic flow information computing systems for intersections and highways.

[11] Tunc, I., Elmas, O., Edem, A., Koroglu, A., Akmese, S., & Soylemez, M. (2021) Traffic Light Signalling with Deep Q Learning Technique.
[12] Krishna, B. H., Patra, P. S. K., & Kalpana, G. (2021, July). Real Time Traffic Light Controlling System Using Morphological Operators and Fuzzy Logic. In Journal of Physics: Conference Series (Vol. 1964, No. 6, p. 062061). IOP Publishing.
[13] Nam, D., Lavanya, R., Jayakrishnan, R., Yang, I., & Jeon, W. H. (2020). A deep learning approach for estimating traffic density using data obtained from connected and autonomous probes. Sensors, 20(17), 4824.
[14] Chandrasekara, W. A. C. J. K., Rathnayaka, R. M. K. T., & Chathuranga, L. L. G. (2020, December). A Real-Time Density-Based Traffic Signal Control System. In 2020 5th International Conference on Information Technology Research (ICITR) (pp. 1-6). IEEE.
[15] Anas, A. M., Terzioglu, H., & Durdu, A. (2020). Intelligent Traffic Signalling Control Using Petri Nets. Artificial Intelligence, 3(1), 1-13.
[16] Osman, T., Psyche, S. S., Ferdous, J. S., & Zaman, H. U. (2017, January). Intelligent traffic management system for cross section of roads using computer vision. In 2017 IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC) (pp. 1-7). IEEE.
[17] Khooban, M. H., Vafamand, N., Liaghat, A., & Dragicevic, T. (2017). An optimal general type-2 fuzzy controller for Urban Traffic Network. ISA transactions, 66, 335-343.
[18] Ferhat Y., Development of image-based vehicle detection system in traffic automation and realization with fpga, 2010.
[19] Özkan I., Erhan U. Deep Learning and Deep Learning Models Used in Image Analysis, Gaziosmanpasa Journal of Scientific Research, 2017.
[20] Krizhevsky, A., Sutskever, I., and Hinton, G. E. (2012). 25th International Conference on Neural Information Processing Systems. ImageNet Classification with Deep Convolutional, 1097–1105. Lake Tahoe, Nevada: NIPS'12 Proceedings.